

**U.S. ENVIRONMENTAL PROTECTION AGENCY  
SUPERFUND DIVISION  
77 WEST JACKSON BOULEVARD  
CHICAGO, ILLINOIS 60604**

EPA Region 5 Records Ctr.



225849

**DATE:** February 8, 2002

**SUBJECT:** Review of Family Golf Centers Data from Argonne National Laboratory and from RSSI

**FROM:** Larry Jensen, CHP  
Regional Radiation Expert  
Emergency Response Section #3

**TO:** Verneta Simon  
On-Scene Coordinator  
Emergency Response Section #3

Fred Micke  
On-Scene Coordinator  
Emergency Response Section #3

Fifty one soil samples were taken by STS Consultants from boreholes at the Family Centers Golf Course and reported in "Radiation Survey, 26-Acre Site, Southwest Corner of Wacker Drive and Lake Shore Drive, Chicago, Illinois" (1-32193-XH, September 19, 2001). These were analyzed with gamma spectroscopy by RSSI. These same samples were delivered by STS to Argonne National Laboratory (ANL) where they were analyzed by gamma spectroscopy again, this time by ANL staff. Data was provided to USEPA by fax and letter.

What follows is a review of that data (see Tables 1 - 6 and Figures 1 - 15 at the end of this report). Issues are discussed at the end of each section.

### COMPARISON OF ANL AND RSSI DATA

**Chart 1: Data Ranges for Ra-226, Ra-228 and Total Radium**

	<b>Ra-226 (pCi/g)</b>	<b>Ra-228 (pCi/g)</b>	<b>Total Radium (pCi/g)</b>
<b>ANL</b>	0.60 - 120	0.29 - 150	1.1 - 191
<b>RSSI</b>	0.22 - 78	0.19 - 87	0.41 - 115

From Tables 1, 2, and 4

Both data sets show some substantially elevated radium concentrations. However, the numerical levels do not agree. This can be seen in detail in Tables 1, 2, and 4.

Figures 2, 4 and 9 show graphically how the ratios of the two data sets compare. Chart 2 shows how the data above the cleanup criterion (7.1 pCi/g) compares.

**Chart 2: Comparison of ANL and RSSI Samples Exceeding Cleanup Criterion**

RSSI Sample No.	ANL Total Radium	RSSI Total Radium	ANL Ra-226	RSSI Ra-226	ANL Ra-228	RSSI Ra-228
12827	191	102	120	66	71	36
12828	140	115	98	78	42	37
12829	182	102	32	15	150	87
12863	20	9.4	4.8	2.1	15	7.3
12868	29	12	4.6	2.2	24	9.7
12897	8.5	8.5	2.3	1.8	6.2	6.7
12898	7.2	14	3.9	1.4	3.3	13
12907	8.9	4.1	6.8	3.0	2.1	1.1

When all samples over the cleanup criterion (7.1 pCi/g) are isolated, it can be seen that ANL and RSSI agree for 7 of 8 samples, out of 51 samples, that the cleanup criterion has been exceeded. For sample 12907, ANL data indicated an exceedence but RSSI did not. For sample 12828 ANL data showed that the cleanup criterion was barely exceeded while RSSI showed it was clearly exceeded. This was due to the large difference in the Ra-228 concentration (3.3 pCi/g vs 12.6 pCi/g).

**Chart 3: Ranges for Ratio of RSSI to ANL Radium Concentrations**

	Ra-226	Ra-228	Total Radium
RSSI / ANL	11 % - 80 %	6 % - 382 %	15 % - 195 %

For Ra-226 RSSI is no more than 80% of ANL's concentration and, at the low end, is only 11% of ANL's concentration. Most data is between about 40% to 80% as seen in Table 1 and Figure 2.

For Ra-228, there is one data point where RSSI is much higher than ANL, 382%. This is for 12.6 pCi/g (RSSI) vs 3.3 pCi/g (ANL). There are three that are close to agreement [108%, 108%, 100%]. These are for RSSI / ANL ratios of 0.573/0.53,

6.71/6.2, and 0.440/0.44, respectively. The remainder of the ratio data is gives RSSI as about 40 % to 90% of ANL as seen by Table 2 and Figure 4.

For Total Radium, there is one RSSI data point that is 195% of ANL (14.02 pCi/g vs 7.2 pCi/g) and one data point of 100% (8.51 pCi/g vs 8.5 pCi/g). Most data is shows RSSI as between 40% and 80% of ANL as seen in Table 4 and Figure 9.

### JUDGMENTS ON THE COMPARISON OF ANL AND RSSI DATA

- For 7 of 8 samples, RSSI and ANL identified the same samples as being elevated over the cleanup criterion.
- In one case, ANL total radium data showed a sample was over criteria but RSSI data did not show this (8.9 pCi/g vs 4.1 pCi/g).
- For one Ra-228 sample, RSSI measured about 4 times the ANL concentration (12.6 pCi/g vs 3.3 pCi/g). This led to this sample being clearly over criterion by RSSI's measurement versus barely over criterion by ANL's measurement (14.02 pCi/g vs 7.2 pCi/g).
- Quantitatively, RSSI and ANL don't agree in about 90% of all cases. RSSI concentrations are generally about 40% to 80% of ANL's concentrations.

### COMPARISON OF RA-228 TO RA-226 CONCENTRATIONS

The ratio of Ra-228 concentrations to Ra-226 concentrations is useful in determining if the contaminated soil is dominated by thorium, the assumed contaminant of concern. This was not established on the Grand Pier property but is worth another test here. Where the ratio exceeds 100%, thorium is the dominant contaminant.

The data can be found in Table 3, Figure 6 and Figure 7.

**Chart 4: Ranges for the Ratio of Ra-228 to Ra-226 Concentrations**

<b>ANL</b>	15% - 522%	8 of 51 samples over 100%
<b>RSSI</b>	37% - 887%	10 of 51 samples over 100%

This chart shows that thorium, as evidenced by Ra-228, dominates for some samples. However, about 80% of all samples have ratios that do not show thorium dominating.

The question can be posed, do the highest ratios go with the highest thorium concentrations?

The following chart is based on Tables 1, 2, 3, and 4 and in Figures 2, 4, 6, 7, and 9.

**Chart 5: Comparison of Highest Ratios of Ra-228 to Ra-226 Concentrations**

<b>RSSI Sample No.</b>	<b>ANL Ratio (%)</b>	<b>RSSI Ratio (%)</b>	<b>ANL Ra-228</b>	<b>RSSI Ra-228</b>	<b>ANL Ra-226</b>	<b>RSSI Ra-226</b>	<b>ANL Total Radium</b>	<b>RSSI Total Radium</b>
12868	522	441	24	9.7	4.6	2.2	29	12
12829	469	564	150	87	32	15	182	102
12906	429	54	3.6	0.23	0.84	0.43	4.4	0.66
12863	313	348	15	7.3	4.8	2.1	20	9.4
12897	270	373	6.2	6.7	2.3	1.8	8.5	8.5
12864	165	148	3.3	2.1	2.0	1.4	5.3	3.5
12869	122	109	3.3	1.5	2.7	1.4	6.0	3.0
12861	111	110	2.0	1.1	1.8	1.0	3.8	2.1
12840	100	79	1.2	0.68	1.2	0.86	2.4	1.5
12898	85	887	3.3	13	3.9	1.4	7.2	14
12905	75	106	0.47	0.34	0.63	0.32	1.1	0.66
12838	89	103	0.73	0.44	0.82	0.42	1.6	0.86

It is apparent that only 4 of 12 high ratios are also associated with high Ra-228 soil concentrations. Thus, high Ra-228 ratios are not necessarily associated with every elevated soil concentration.

The converse of the question is are high Ra-228 soil concentrations associated with high ratios?

**Chart 6: Comparison of Highest Ra-228 Concentrations to Ra-228 / Ra-226 Ratios**

<b>RSSI Sample No.</b>	<b>ANL Ra-228</b>	<b>RSSI Ra-228</b>	<b>ANL Ratio (%)</b>	<b>RSSI Ratio (%)</b>	<b>ANL Ra-226</b>	<b>RSSI Ra-226</b>	<b>ANL Total Radium</b>	<b>RSSI Total Radium</b>
12829	150	87	469	564	32	15	182	102
12827	71	36	59	55	120	66	191	102
12828	42	37	43	47	98	78	140	115
12868	24	9.7	522	441	4.6	2.2	29	12
12863	15	7.3	313	348	4.8	2.1	20	9.4
12897	6.2	6.7	270	373	2.3	1.8	8.5	8.5
12898	3.3	13	85	887	3.9	1.4	7.5	14

For the ANL data, the data does not show a consistent association of high Ra-228 concentration and high Ra-228/Ra-226 ratio. The same is true for the RSSI data. In both cases, the highest Ra-228 concentrations are not associated with the highest ratios.

**JUDGMENTS ON THE COMPARISON OF RA-228 TO RA-226 CONCENTRATIONS**

- It is not apparent in either the ANL nor the RSSI soil concentration data that high Ra-228 concentrations are consistently associated with high Ra-228/Ra-226 ratios. Thus, the sites of contamination do not consistently show Ra-228 dominates over Ra-226.
- As with the Grand Pier data, even where contaminated soil is known to be associated with thorium contamination, Ra-228 will not necessarily always be dominant over Ra-226. This is probably an artifact of the chemical processing where some portions are concentrated in Ra-228 and some in Ra-226.

**RECOMMENDATION**

Discussions or a meeting with staff of ANL and RSSi is necessary to determine why the two data sets do not agree. Firm judgments on contamination should not be made until this is resolved

GOLF COURSE SOIL SAMPLES  
 ARGONNE NATIONAL LABORATORY / RSSI DATA  
 Family Golf Centers

TABLE 1

RSSI SAMPLE NO.	ANL SAMPLE NO.	ANL Ra-226	RSSI Ra-226	RSSI/ANL	SORTED RSSI/ANL
12824	02-8026-1	1.9	1.05	55%	80%
12825	02-8026-2	1.8	1.12	62%	78%
12826	02-8026-3	1.6	1.15	72%	74%
12827	02-8026-4	120	65.6	55%	74%
12828	02-8026-5	98	78.0	80%	74%
12829	02-8026-6	32	15.4	48%	73%
12830	02-8026-7	2.6	1.32	51%	72%
12831	02-8026-8	3.0	1.52	51%	72%
12832	02-8026-9	1.4	0.856	61%	71%
12833	02-8026-10	1.5	1.11	74%	66%
12834	02-8026-11	1.2	0.689	57%	66%
12835	02-8026-12	0.69	0.363	53%	65%
12836	02-8026-13	2.0	1.09	55%	65%
12837	02-8026-14	2.8	1.46	52%	63%
12838	02-8026-15	0.82	0.424	52%	62%
12839	02-8026-16	1.0	0.735	74%	62%
12840	02-8026-17	1.2	0.864	72%	61%
12841	02-8026-18	1.2	0.791	66%	60%
12842	02-8026-19	1.4	0.729	52%	60%
12843	02-8026-20	1.8	1.31	73%	60%
12861	02-8026-21	1.8	1.01	56%	58%
12862	02-8026-22	1.7	1.07	63%	58%
12863	02-8026-23	4.8	2.09	44%	58%
12864	02-8026-24	2.0	1.41	71%	58%
12865	02-8026-25	1.4	0.868	62%	57%
12866	02-8026-26	1.8	1.04	58%	56%
12867	02-8026-27	1.5	0.761	51%	55%
12868	02-8026-28	4.6	2.20	48%	55%
12869	02-8026-29	2.7	1.41	52%	55%
12870	02-8026-30	1.9	1.24	65%	55%
12896	02-8026-31	1.1	0.719	65%	53%
12897	02-8026-32	2.3	1.80	78%	53%
12898	02-8026-33	3.9	1.42	36%	52%
12899	02-8026-34	1.3	0.756	58%	52%
12900	02-8026-35	1.1	0.658	60%	52%
12901	02-8026-36	0.73	0.420	58%	52%
12902	02-8026-37	0.6	0.361	60%	52%
12903	02-8026-38	2	0.216	11%	52%
12904	02-8026-39	0.74	0.372	50%	51%
12905	02-8026-40	0.63	0.320	51%	51%
12906	02-8026-41	0.84	0.431	51%	51%
12907	02-8026-42	6.8	2.98	44%	51%
12908	02-8026-43	4.1	2.14	52%	51%
12909	02-8026-44	2.6	1.55	60%	50%
12910	02-8026-45	1.4	0.652	47%	48%
12911	02-8026-46	1.8	1.19	66%	48%
12912	02-8026-47	2.4	1.39	58%	47%
12913	02-8026-48	1.6	0.855	53%	44%
12914	02-8026-49	1.8	0.992	55%	44%
12915	02-8026-50	1.9	0.981	52%	36%
12916	02-8026-51	1.4	1.03	74%	11%

FIGURE 1

Golf Course Data, Ra-226

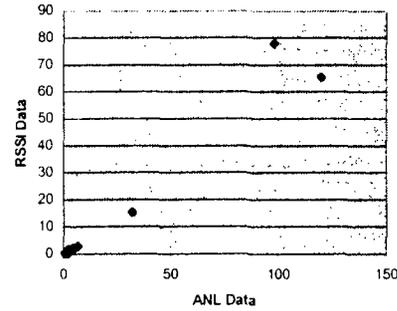
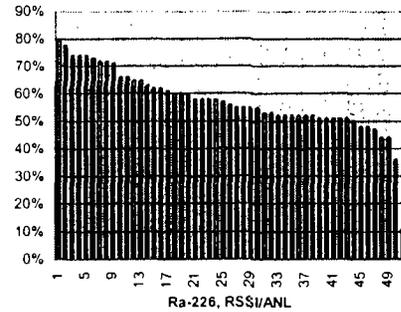


FIGURE 2

Golf Course Data, Ra-226, RSSI/ANL



GOLF COURSE SOIL SAMPLES  
 ARGONNE NATIONAL LABORATORY / RSSI DATA  
 Family Golf Centers

TABLE 2

RSSI SAMPLE NO.	ANL SAMPLE NO.	ANL Ra-228	RSSI Ra-228	RSSI/ANL	SORTED RSSI/ANL
12824	02-8026- 1	1.7	0.935	55%	382%
12825	02-8026- 2	1.6	1.08	68%	108%
12826	02-8026- 3	1.3	0.887	68%	108%
12827	02-8026- 4	7.1	36.3	51%	100%
12828	02-8026- 5	42	36.6	87%	91%
12829	02-8026- 6	150	86.8	58%	87%
12830	02-8026- 7	2.3	1.16	50%	80%
12831	02-8026- 8	1.8	0.949	53%	75%
12832	02-8026- 9	1.2	0.675	56%	72%
12833	02-8026- 10	0.85	0.676	80%	70%
12834	02-8026- 11	1.0	0.556	56%	68%
12835	02-8026- 12	0.51	0.315	62%	68%
12836	02-8026- 13	1.4	0.942	67%	67%
12837	02-8026- 14	2.0	1.07	54%	66%
12838	02-8026- 15	0.73	0.435	60%	66%
12839	02-8026- 16	0.44	0.440	100%	66%
12840	02-8026- 17	1.2	0.684	57%	64%
12841	02-8026- 18	0.53	0.573	108%	63%
12842	02-8026- 19	0.81	0.377	47%	62%
12843	02-8026- 20	0.73	0.481	66%	60%
12861	02-8026- 21	2.0	1.11	56%	60%
12862	02-8026- 22	0.88	0.80	91%	60%
12863	02-8026- 23	15	7.28	49%	59%
12864	02-8026- 24	3.3	2.09	63%	59%
12865	02-8026- 25	0.94	0.500	53%	59%
12866	02-8026- 26	1.5	0.890	59%	58%
12867	02-8026- 27	0.99	0.559	56%	57%
12868	02-8026- 28	24	9.71	40%	57%
12869	02-8026- 29	3.3	1.54	47%	57%
12870	02-8026- 30	1.5	0.96	64%	56%
12896	02-8026- 31	0.65	0.385	59%	56%
12897	02-8026- 32	6.2	6.71	108%	56%
12898	02-8026- 33	3.3	12.6	382%	56%
12899	02-8026- 34	0.94	0.554	59%	55%
12900	02-8026- 35	0.82	0.465	57%	54%
12901	02-8026- 36	0.55	0.365	66%	54%
12902	02-8026- 37	0.51	0.306	60%	53%
12903	02-8026- 38	0.29	0.191	66%	53%
12904	02-8026- 39	0.58	0.348	60%	52%
12905	02-8026- 40	0.47	0.339	72%	52%
12906	02-8026- 41	3.6	0.232	6%	52%
12907	02-8026- 42	2.1	1.09	52%	51%
12908	02-8026- 43	1.7	0.865	51%	51%
12909	02-8026- 44	1.8	0.925	51%	51%
12910	02-8026- 45	1.1	0.569	52%	50%
12911	02-8026- 46	1.4	1.05	75%	49%
12912	02-8026- 47	1.7	0.975	57%	49%
12913	02-8026- 48	0.97	0.501	52%	47%
12914	02-8026- 49	1.4	0.683	49%	47%
12915	02-8026- 50	1.3	0.706	54%	40%
12916	02-8026- 51	0.99	0.690	70%	6%

FIGURE 3

Golf Course Data, Ra-228

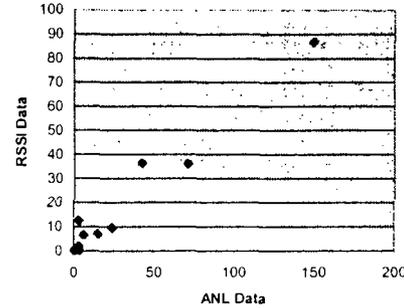
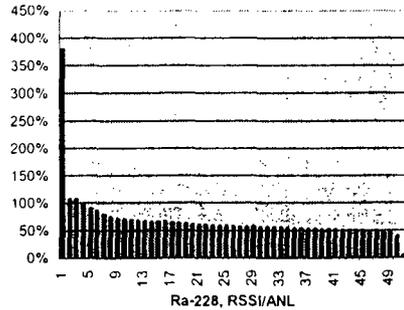


FIGURE 4

Golf Course Data, Ra-228, RSSI/ANL



GOLF COURSE SOIL SAMPLES  
 ARGONNE NATIONAL LABORATORY / RSSI DATA  
 Family Golf Centers

TABLE 3

RSSI SAMPLE NO.	ANL SAMPLE NO.	SORTED		RSSI Ra-228/ RA-226	SORTED RSSI Ra-228/ RA-226
		ANL Ra-228/ RA-226	ANL Ra-228/ RA-226		
12824	02-8026-1	89%	522%	89%	887%
12825	02-8026-2	89%	469%	96%	564%
12826	02-8026-3	81%	429%	77%	441%
12827	02-8026-4	59%	313%	55%	373%
12828	02-8026-5	43%	270%	47%	348%
12829	02-8026-6	469%	165%	564%	148%
12830	02-8026-7	88%	122%	88%	110%
12831	02-8026-8	60%	111%	62%	109%
12832	02-8026-9	86%	100%	79%	106%
12833	02-8026-10	57%	89%	61%	103%
12834	02-8026-11	83%	89%	81%	96%
12835	02-8026-12	74%	89%	87%	94%
12836	02-8026-13	70%	88%	86%	89%
12837	02-8026-14	71%	86%	73%	88%
12838	02-8026-15	89%	85%	103%	88%
12839	02-8026-16	44%	85%	60%	88%
12840	02-8026-17	100%	83%	79%	87%
12841	02-8026-18	44%	83%	72%	87%
12842	02-8026-19	58%	81%	52%	87%
12843	02-8026-20	41%	79%	37%	86%
12861	02-8026-21	111%	79%	110%	86%
12862	02-8026-22	52%	78%	75%	85%
12863	02-8026-23	313%	78%	348%	81%
12864	02-8026-24	165%	78%	148%	79%
12865	02-8026-25	67%	75%	58%	79%
12866	02-8026-26	83%	75%	86%	78%
12867	02-8026-27	66%	75%	73%	77%
12868	02-8026-28	522%	74%	441%	75%
12869	02-8026-29	122%	72%	109%	73%
12870	02-8026-30	79%	71%	78%	73%
12896	02-8026-31	59%	71%	54%	73%
12897	02-8026-32	270%	71%	373%	72%
12898	02-8026-33	85%	70%	887%	72%
12899	02-8026-34	72%	69%	73%	71%
12900	02-8026-35	75%	68%	71%	70%
12901	02-8026-36	75%	67%	87%	69%
12902	02-8026-37	85%	66%	85%	67%
12903	02-8026-38	15%	61%	88%	62%
12904	02-8026-39	78%	60%	94%	61%
12905	02-8026-40	75%	59%	106%	60%
12906	02-8026-41	429%	59%	54%	60%
12907	02-8026-42	31%	58%	37%	59%
12908	02-8026-43	41%	57%	40%	58%
12909	02-8026-44	69%	52%	60%	55%
12910	02-8026-45	79%	44%	87%	54%
12911	02-8026-46	78%	44%	88%	54%
12912	02-8026-47	71%	43%	70%	52%
12913	02-8026-48	61%	41%	59%	47%
12914	02-8026-49	78%	41%	69%	40%
12915	02-8026-50	68%	31%	72%	37%
12916	02-8026-51	71%	15%	67%	37%

FIGURE 5

Golf Course Data, Ra-228/Ra-226

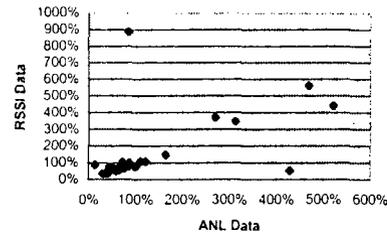


FIGURE 6

Golf Course Data, ANL, Ra-228/Ra-226

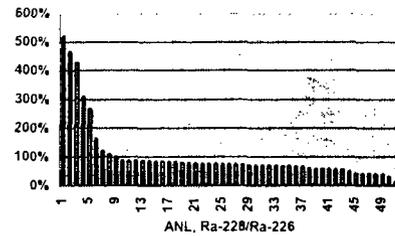
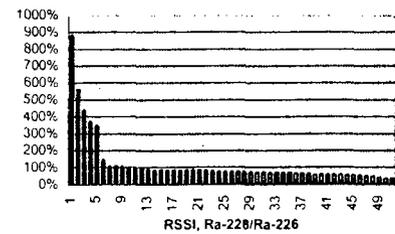


FIGURE 7

Golf Course Data, RSSI, Ra-228/Ra-226



GOLF COURSE SOIL SAMPLES  
 ARGONNE NATIONAL LABORATORY / RSSI DATA  
 Family Golf Centers

TABLE 4

RSSI SAMPLE NO.	ANL SAMPLE NO.	ANL TOTAL RADIUM	RSSI TOTAL RADIUM	RSSI/ANL	SORTED RSSI/ANL	
12824	02-8026-	1	3.6	1.99	55%	195%
12825	02-8026-	2	3.4	2.20	65%	100%
12826	02-8026-	3	2.9	2.037	70%	82%
12827	02-8026-	4	191	101.9	53%	82%
12828	02-8026-	5	140	114.6	82%	79%
12829	02-8026-	6	182	102.2	56%	76%
12830	02-8026-	7	4.9	2.48	51%	73%
12831	02-8026-	8	4.8	2.469	51%	72%
12832	02-8026-	9	2.6	1.531	59%	71%
12833	02-8026-	10	2.35	1.786	76%	70%
12834	02-8026-	11	2.2	1.245	57%	70%
12835	02-8026-	12	1.2	0.678	57%	66%
12836	02-8026-	13	3.4	2.032	60%	65%
12837	02-8026-	14	4.8	2.53	53%	65%
12838	02-8026-	15	1.55	0.859	55%	65%
12839	02-8026-	16	1.44	1.175	82%	63%
12840	02-8026-	17	2.4	1.548	65%	61%
12841	02-8026-	18	1.73	1.364	79%	60%
12842	02-8026-	19	2.21	1.106	50%	60%
12843	02-8026-	20	2.53	1.791	71%	60%
12861	02-8026-	21	3.8	2.12	56%	59%
12862	02-8026-	22	2.58	1.874	73%	58%
12863	02-8026-	23	19.8	9.37	47%	58%
12864	02-8026-	24	5.3	3.50	66%	58%
12865	02-8026-	25	2.34	1.368	58%	58%
12866	02-8026-	26	3.3	1.93	58%	58%
12867	02-8026-	27	2.49	1.32	53%	57%
12868	02-8026-	28	28.6	11.91	42%	57%
12869	02-8026-	29	6.0	2.95	49%	56%
12870	02-8026-	30	3.4	2.203	65%	56%
12896	02-8026-	31	1.75	1.104	63%	56%
12897	02-8026-	32	8.5	8.51	100%	55%
12898	02-8026-	33	7.2	14.02	195%	55%
12899	02-8026-	34	2.24	1.31	58%	55%
12900	02-8026-	35	1.92	1.123	58%	53%
12901	02-8026-	36	1.28	0.785	61%	53%
12902	02-8026-	37	1.11	0.667	60%	53%
12903	02-8026-	38	2.29	0.407	18%	53%
12904	02-8026-	39	1.32	0.720	55%	53%
12905	02-8026-	40	1.1	0.659	60%	52%
12906	02-8026-	41	4.44	0.663	15%	52%
12907	02-8026-	42	8.9	4.07	46%	51%
12908	02-8026-	43	5.8	3.005	52%	51%
12909	02-8026-	44	4.4	2.475	56%	50%
12910	02-8026-	45	2.5	1.221	49%	49%
12911	02-8026-	46	3.2	2.24	70%	49%
12912	02-8026-	47	4.1	2.365	58%	47%
12913	02-8026-	48	2.57	1.356	53%	46%
12914	02-8026-	49	3.2	1.675	52%	42%
12915	02-8026-	50	3.2	1.687	53%	18%
12916	02-8026-	51	2.39	1.720	72%	15%

FIGURE 8

Golf Course Data, Total Radium

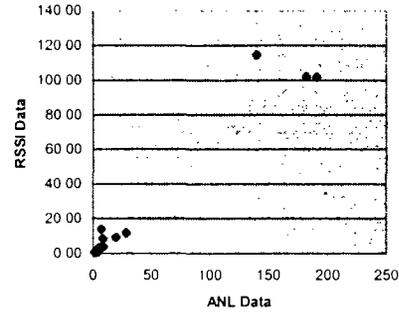
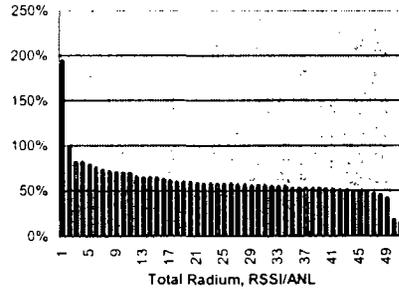


FIGURE 9

Golf Course Data, Total Radium,  
RSSI/ANL



GOLF COURSE SOIL SAMPLES  
 ARGONNE NATIONAL LABORATORY / RSSI DATA  
 Family Golf Centers

TABLE 5

SORTED ANL Ra-226	SORTED ANL Ra-228	SORTED ANL TOTAL RADIUM
120	150	191
98	71	182
32	42	140
6.8	24	28.6
4.8	15	19.8
4.6	6.2	14
4.1	3.6	8.9
3.9	3.3	8.5
3.0	3.3	7.2
2.8	3.3	6.0
2.7	2.3	5.8
2.6	2.1	5.3
2.6	2.0	4.9
2.4	2.0	4.8
2.3	1.8	4.8
2.0	1.8	4.44
2.0	1.7	4.4
2.0	1.7	4.1
1.9	1.7	3.8
1.9	1.6	3.4
1.9	1.5	3.4
1.8	1.5	3.4
1.8	1.4	3.33
1.8	1.4	3.2
1.8	1.4	3.2
1.8	1.3	3.2
1.8	1.3	2.9
1.7	1.2	2.6
1.6	1.2	2.58
1.6	1.1	2.57
1.5	1.0	2.53
1.5	0.99	2.5
1.4	0.99	2.49
1.4	0.97	2.4
1.4	0.94	2.39
1.4	0.94	2.35
1.4	0.88	2.34
1.3	0.85	2.29
1.2	0.82	2.24
1.2	0.81	2.21
1.2	0.73	2.2
1.1	0.73	1.92
1.1	0.65	1.75
1.0	0.58	1.73
0.84	0.55	1.55
0.82	0.53	1.44
0.74	0.51	1.32
0.73	0.51	1.28
0.69	0.47	1.2
0.63	0.44	1.11
0.60	0.29	1.1

FIGURE 10

Sorted ANL Golf Course Data

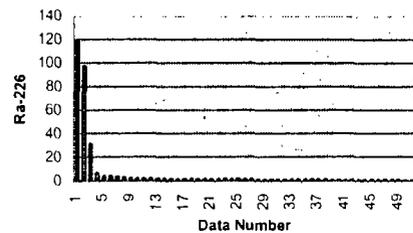


FIGURE 11

Sorted ANL Golf Course Data

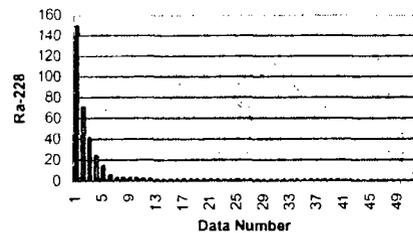
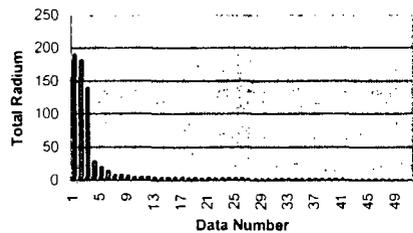


FIGURE 12

Sorted ANL Golf Course Data



GOLF COURSE SOIL SAMPLES  
 ARGONNE NATIONAL LABORATORY / RSSI DATA  
 Family Golf Centers

TABLE 6

SORTED RSSI Ra-226	SORTED RSSI Ra-228	RSSI TOTAL RADIUM
78.0	86.8	115
65.6	36.6	102
15.4	36.3	102
2.98	12.6	14
2.20	9.71	12
2.14	7.28	9.37
2.09	6.71	8.51
1.80	2.09	4.07
1.55	1.54	3.50
1.52	1.16	3.01
1.46	1.11	2.95
1.42	1.09	2.53
1.41	1.08	2.48
1.41	1.07	2.48
1.39	1.05	2.47
1.32	0.975	2.37
1.31	0.96	2.24
1.24	0.949	2.20
1.19	0.942	2.20
1.15	0.935	2.12
1.12	0.925	2.04
1.11	0.890	2.03
1.09	0.887	1.99
1.07	0.865	1.93
1.05	0.80	1.87
1.04	0.706	1.79
1.03	0.690	1.79
1.01	0.684	1.72
0.992	0.683	1.69
0.981	0.676	1.68
0.868	0.675	1.55
0.864	0.573	1.53
0.856	0.569	1.37
0.855	0.559	1.36
0.791	0.556	1.36
0.761	0.554	1.32
0.756	0.501	1.31
0.735	0.500	1.25
0.729	0.481	1.22
0.719	0.465	1.18
0.689	0.440	1.12
0.658	0.435	1.11
0.652	0.385	1.10
0.431	0.377	0.859
0.424	0.365	0.785
0.420	0.348	0.720
0.372	0.339	0.678
0.363	0.315	0.667
0.361	0.306	0.663
0.320	0.232	0.659
0.216	0.191	0.407

FIGURE 13

Sorted RSSI Golf Course Data

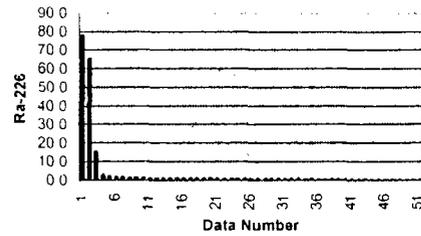


FIGURE 14

Sorted RSSI Golf Course Data

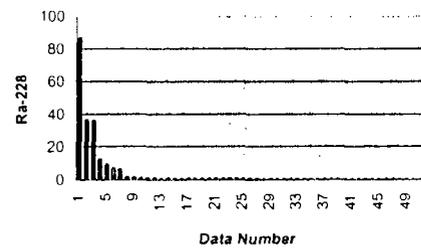


FIGURE 15

Sorted RSSI Golf Course Data

